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AN EVALUATION OF FOREST INSECT AND DISEASE RESEARCH NEEDS IN OREGON AND WASHINGTON

PART I - INSECTS

By

Northwest Forest Pest Action Committee

November 1953

The Northwest Forest Pest Action Committee is composed of representatives of the following organizations:

Associated Forest Industries of Oregon

Bureau of Entomology and Plant Quarantine

Bureau of Land Management

Bureau of Plant Industry

Forest Service

Indian Service

Industrial Forestry Association

Keep Oregon Green Association

Keep Washington Green Association

Oregon Extention Service

Oregon Forest Fire Association

Oregon State Board of Forestry

Oregon State College

Soil Conservation Service

Southern Oregon Conservation and Tree Farm Association

State College of Washington

Tree Farm Management Service

University of Washington

Washington Forest Fire Association

Washington State Division of Forestry

Western Forest Industries Association

Western Forestry and Conservation Association

Western Pine Association

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FOREWORD

The Northwest Forest Pest Action Committee has become increasingly alarmed over the destruction caused by insects and diseases in the forests of the Pacific Northwest. While less spectacular than forest fires, insects and diseases take a terrific death toll in our forests. According to the best estimates available, the timber killed annually by insects and diseases exceeds 2 billion board feet or 1/5 of the yearly log production in Oregon and Washington. In these two states the forest industries are primary in their contribution to employment, regional income and economic stability of business and the welfare of the people.

The Northwest Forest Pest Action Committee has taken leadership in promoting the control of destructive forest insects in the region, such as the spruce budworm, the Douglas fir beetle, the western pine beetle, and others. Realizing, that more information is needed to understand the behavior and control of insects and diseases, the Committee established on December 11, 1952 an Insect and Disease Research Sub-Committee. At its first meeting the Research Sub-Committee defined its responsibilities as follows:

(1) To evaluate the need for research on forest insects and diseases in Oregon and Washington.

(2) To determine the extent and quality of insect and disease research of the various public and private organizations.

(3) To recommend and promote research programs in the two states in order that a coordinated, objective, aggressive and comprehensive approach to solving our insect and disease problems be developed as rapidly as possible.

(4) To stimulate the dissemination of insect and disease research information to the various public and private organizations.

To meet these objectives, the Insect and Disease Research Sub-Committee has prepared separate reports on insect and disease research problems. Part I on insects follows.

The Northwest Forest Pest Action Committee has adopted this report as the best evaluation of the current needs for research on forest insects presently available. Further, it believes that the fulfillment of its recommendations will result in a more realistic and effective approach to solving the Northwest's forest insect problems.

E. L. Kolbe, Chairman
Northwest Forest Pest Action Committee

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SUMMARY AND RECOMMENDATIONS

Insect control is one of the principal forest management problems in Oregon and Washington. In these two states for the past decade insects of all kinds have killed an estimated 1-3/4 billion board feet of timber annually. Insects also cause serious damage in the form of delayed regeneration, sparse stocking, reduced growth, degraded lumber, and damaged forest products.

The damage differs in kind and amount from year to year, depending upon the epidemic status of the principal destructive insects. Some insects, such as the western pine beetle, cause extensive killing every year. Others, like the pine butterfly, cause economic losses only at long intervals. During the early 1930's the western pine beetle alone killed almost as much timber as was cut. In 1951 the Douglas fir beetle killed over one billion board feet of timber. Recently the spruce budworm has threatened the Pacific Northwest's Douglas fir and white fir forests, making necessary a control program that has continued for five years and has already cost over $3,350,000.

The prevention and control of insect outbreaks is both difficult and complex. Before effective control measures can be developed, the habits of the insects and their relationship to the forest must be determined. Even after effective control measures are developed it is necessary to know when and where to apply them and when to stop. Much basic research is required.

In assessing the research needs the Committee has reviewed what has been done. It finds that the accomplishments have been large in the 50 years that the forest insects of the region have been studied. During this period the Bureau of Entomology and Plant Quarantine has conducted most of the research. Recently the Oregon State Board of Forestry, Weyerhaeuser Timber Company, and others have made valuable contributions.

The early investigators identified the principal insects, studied the biology of some, evaluated their damage and worked out methods of direct control. Chief attention was given to bark beetles, especially the western pine beetle. Efforts to improve direct control methods are continuing.

While the direct control methods were being developed, experiments were undertaken to effect control through forest management. Out of these experiments, selective cutting methods for the removal of beetle susceptible trees in ponderosa pine were tested and now are a basic part of the cutting practices in the pine region.

In the early 1930's aerial dusting was undertaken against the hemlock looper. However, it was not until the development of DDT and aerial spraying that the control of forest defoliators became really practical. Now some destructive insects, such as the spruce budworm, Douglas fir tussock moth and hemlock looper, can be controlled by aerial spraying. Further research is needed to improve the present techniques and to adapt them to other insects.

Aerial surveys to detect and evaluate forest insect outbreaks are a recent development. Much remains to be done in the improvement of techniques but already aerial surveys, together with ground surveys, have done much to strengthen the

forest insect protection program of the region. For example, Table I shows the status of the principal insects in 1952, as revealed by the survey conducted cooperatively by the federal and state governments and private timber owners(19).

The Committee recognizes that much progress has been made in forest insect research and that expanded efforts are being made, but it feels that a greatly accelerated research program is necessary. In submitting its report the Committee calls attention to the principal problems needing research. It hopes that more individuals and organizations will undertake some of the work and thereby prepare the way for better protection against forest insects.

At best it will take a long time to solve even the major insect problems of Oregon and Washington. Therefore the timely ones of greatest economic importance should be studied first. With this in mind the Committee has outlined the problems on a priority basis. First, there are the basic studies that relate to most of the individual insect problems. Second, there are the widely destructive insects that require major attention immediately. Third comes a group of insects of lesser importance but which needs current study. Fourth are the insects which for one reason or another can be studied later.

The order of economic importance may change from time to time, depending upon the status of the insects and the progress of research. Some insects now low on the list potentially are very destructive and ultimately should be studied in order to be ready for the day they may become epidemic. Some insects not included on the list may eventually need to be studied. Circumstances will dictate what research is done. Some organizations can study only certain types of problems, which may be relatively low in priority. They should do what they can.

In summary the Committee recommends:

1. That research be undertaken to:

    a. Improve and extend aerial and ground survey methods for detecting and evaluating forest insect outbreaks.

    b. Develop and improve chemical control methods.

    c. Investigate the principal insects along the following lines:

        (1) Conduct biological studies of the species not yet fully investigated.

        (2) Intensify studies of natural control by parasites, predators and diseases.

        (3) Investigate and develop forest management practices as a method of control.

        (4) Investigate individual tree and stand resistance to insect attacks, including genetics studies to develop insect-resistant trees.

2. That the proposed research be implemented by:

    a. Strengthening the present research organizations by providing adequate financing and staffing.

b. Encouraging additional organizations to participate in forest insect research.

c. Placing increased emphasis on practical entomological training in the forestry schools, both for students and short term trainees.

d. Providing technical guidance and in-service training for foresters not specially trained in entomology so they can conduct part of the needed research and surveys.

3. That the research efforts be coordinated through annual reviews and evaluations by the Northwest Forest Pest Action Committee.

4. That the research findings be promptly disseminated by:

a. Timely project reports and publications by the research workers.

b. An annual summary of progress to be prepared and distributed by the Northwest Forest Pest Action Committee.

c. Public news releases.

GENERAL FOREST INSECT RESEARCH PROBLEMS

Some survey and chemical control problems are common to the detection and control of many forest insects. These basic problems are presented in this section. Detailed survey and control problems that have limited application are covered in the sections relating to specific insects.

FOREST INSECT SURVEYS

Importance of Problem

Surveys are essential for an adequate program of protecting forests against destruction by insects. Surveys provide the information that is necessary for undertaking and evaluating control operations against forest insects, both native and introduced. Surveys provide loss statistics which are basic to sound forest management.

The numerous destructive forest insects in Oregon and Washington affect the forests in different ways. Different insects and forest types each present special survey problems. Specific techniques must be developed for each insect and each forest condition; coordinated survey schedules must be devised; and detection crews must be trained. Research provides the methods.

Research to Date

Forest insect surveys have been made in the Northwest for more than fifty years. The first surveys were sporadic look-see examinations by federal entomologists to determine what insects were active and what damage they were causing. The entomologists soon found that detailed studies of the insects were necessary in order to assess the outbreaks and to develop control measures.

Biologists first concentrated their efforts on studies of the western pine beetle, a study that was sparked by the tremendous destruction that was occurring in the pine stands of the western states. It was during the studies made on this insect that the first permanent ground plots were established in the 1920's. These plots and many others subsequently established are still an important part of the regional survey program. Gradually methods for making ground surveys of other insects, such as the mountain pine beetle, were developed and put into practice.

The use of the airplane to make forest insect surveys was considered as early as the late twenties. Limited progress was made in the use of this valuable survey method until the nineteen-forties, when the first region-wide aerial surveys were completed. This marked an important advance in forest insect detection. Studies were undertaken to develop and improve techniques for making aerial surveys. Much progress has been made with such insects as the spruce budworm and Douglas fir beetle (13)[1/]. Now the airplane is recognized as an essential tool for making surveys of the large forest areas in Oregon and Washington. Many timber stands cannot be economically surveyed in any other manner.

1/ Numbers in parentheses refer to the Bibliography, page 24.

Research Needs

Practical detection survey methods have been developed for most of the more destructive insects. Less progress has been made on evaluation surveys, particularly those for evaluating population trends. Most of the present survey methods should be improved for greater accuracy and economy. Special studies are needed and are in progress to improve Douglas fir beetle and fir engraver beetle surveys which so far are relatively undeveloped. Specific points needing investigation are listed below:

A. Ground Surveys

1. A determination of the intensity of coverage is needed for detecting insect epidemics. Research is needed to determine the size and number of plots required to provide reliable information.

2. An analysis is needed of the value of plots for indicating insect population trends. The frequency of plot observation should also be established.

3. A study should be conducted for each insect to determine the best method to evaluate population densities.

B. Aerial Surveys

1. Aerial photography. The current studies should be continued and expanded as follows:

   a. The findings of completed aerial photo tests for evaluating damage caused by bark beetles should be summarized and issued.

   b. Additional research is needed to determine the best film, filter, photo scale and time of year for recording damage by specific insects.

   c. Aerial photo sampling procedures need to be developed by determining the number, size and shape of plots required for sampling given conditions.

2. Survey aids. Additional study is needed to develop survey aids for simplifying and increasing the accuracy of aerial surveys, such as:

   a. Recording devices which will simplify the observer's mapping task.

   b. Strip viewers and other devices to permit more accurate estimate of insect damages on areas being surveyed.

   c. Colored glasses or other optical aids.

C. Training Methods

Research is needed to establish the best training methods to use when instructing new observers. Standardizing the classification of of degree of damage or infestation will help to improve training techniques.

Research Priorities

The Committee recommends that emphasis be given to the development and improvement of aerial surveys, but not to the detriment of the essential ground surveys. Survey methods for the Douglas fir beetle and fir engraver beetles also should be given high priority.

CHEMICAL CONTROL TECHNIQUES

Importance of Problem

Many forest insects are susceptible to effective and economical control through the use of chemicals. However, full advantage cannot always be taken of these control possibilities because comparatively little research has been done to find suitable insecticides and to develop techniques for their application.

In three instances in the past eight years this lack of research has been demonstrated in the Northwest. The hemlock looper outbreak in Clatsop County, Oregon in 1945; the Douglas fir tussock moth outbreak in Idaho and Oregon in 1947; and the current spruce budworm epidemic in Oregon and Washington were all serious epidemics demanding immediate control measures. These outbreaks were controlled through the aerial application of chemicals. However, the manner in which these chemicals were applied was largely guesswork because of the lack of prior research, and, in the case of the budworm epidemic, control efforts had to be delayed until research could be done.

It is expected that through a coordinated research program basic data on chemicals and their use can be obtained in advance of future epidemics.

Research to Date

A. Laboratory and Field Testing of Insecticides.

Standard laboratory procedures for screening candidate insecticides against representative insect pests have been developed and each year numerous tests are conducted. Unfortunately no forest insects are used in these standardized tests. It is highly desirable that one or more forest insects be included in the tests.

No standard procedures for the testing of insecticides under forest conditions are available. However, much research in this field has been done on specific problems by improvised methods. An example of this type of work was the group of experiments conducted cooperatively by the Bureau of Entomology and Plant Quarantine, the Forest Service, the Oregon State Board of Forestry, and Kinzua Pine Mills Company through

which the aerial application of DDT was tested as a control for the spruce budworm. Insecticides have also been tested against other important northwestern forest insects, such as the mountain pine beetle, Engelmann spruce beetle, western pine beetle, hemlock looper, and Douglas fir tussock moth.

B. Development of Aerial and Ground Application Techniques.

The Beltsville laboratory of the Bureau of Entomology and Plant Quarantine has done a great deal of work during the past several years to develop and test apparatus and techniques for the aerial application of insecticides against forest insects. In addition to work done at the laboratory, Beltsville personnel have assisted the regional laboratories in field experiments.

Most of the research in the ground application of insecticides has been conducted by the regional laboratories. Tests using chemicals, in penetrating oils, against the mountain pine beetle and the western pine beetle are examples of this type of research.

Research Needs

The following are the more important general problems in the field of chemical control which need attention:

1. The development of standard techniques for the laboratory screening of insecticides for forest insects. Each year many new insecticides are offered by chemical concerns as possible insecticides for forest insects. Standardized procedures for testing these insecticides against selected forest insects should be developed.

2. The development of techniques for the field testing of insecticides. Past field tests of insecticides, such as those conducted in the Northwest against the hemlock looper and the spruce budworm, have been large-scale project experiments. Such experiments are costly and the results are extremely difficult to evaluate. Carefully designed small-scale field testing techniques would permit a greater variety of tests that would yield results more rapidly and at less cost.

3. Further testing and evaluation of aerial application techniques. Information relative to the aerial application of insecticides is needed on the following points:

a. A precise evaluation of the relative efficiency and limitations of the various types of aircraft used in forest spraying.

b. Accurate information on the minimum insecticide deposits necessary for control.

c. Further information on maximum and minimum spray application heights for various types of airplanes.

d. Further information on the timing of aerial applications.

4. Development of ground application techniques. Certain insects cannot be controlled through aerial application of insecticides. Effective techniques for ground control of these insects are urgently needed.

Research Priorities

Since effective insecticides are the first prerequisite for insect control, the development of laboratory and field insecticide testing techniques should be given priority over the development of application procedures.

SPECIFIC INSECT PROBLEMS

For convenience in reviewing research needs of specific insects, the discussion of the problems that follow has been divided into three priority groups. The grouping by priorities is based upon the relative importance or seriousness of the current problem for each of the various insects.

First Priority Group

The insects in this group are widely destructive. Research should be conducted on a full scale immediately and carried forward until the problems are solved.

SPRUCE BUDWORM

Importance of Problem

The spruce budworm (4) (12) is one of the most widely distributed and destructive forest insects in North America. It kills Douglas fir, true firs and spruces by repeated defoliation and by inducing the attacks of bark beetles. The current epidemic of the budworm in Oregon and Washington began in 1944 and is by far the most extensive on record in these states. Killing has been kept to a low level by spraying 3,152,000 acres at a total cost of about $3,350,000. On unsprayed areas the outbreak is continuing and the budworm still poses a threat to the forest industry of the region. Since aerial spraying is too expensive to continue indefinitely, some less costly means of preventing or controlling outbreaks is urgently needed. Studies of the spruce budworm and its control are high on the list of research needs.

Research to Date

The spruce budworm has been studied for many years, particularly in the Eastern United States and Canada. In Oregon and Washington detailed attention was first given to this insect in 1947 when the seriousness of the current epidemic became apparent. Cooperative studies conducted since that time by the Bureau of Entomology and Plant Quarantine, U. S. Forest Service, Oregon State Board of Forestry, and private timberland owners have yielded the following results:

a. The general life history of the insect has been determined (5).

b. A workable aerial survey procedure has been devised.

c. An effective and economical chemical control technique has been developed and applied (8).

In addition, the following studies are currently being conducted:

a. The Bureau of Entomology and Plant Quarantine, in cooperation with federal, state and private agencies has established a series of

semi-permanent sample plots for evaluating outbreak trends.

b. Since 1948 the Bureau of Entomology and Plant Quarantine has been studying the effects of parasites upon the spruce budworm.

c. Since 1951 the Oregon State Board of Forestry has been studying the effects of temperatures and relative humidity upon the development of spruce budworm larvae.

Research Needs

Listed below are problems relating to the spruce budworm for which answers are urgently needed.

A. Biological Studies

1. Information is needed on the dispersal characteristics of the insect. This applies to the development and spread of outbreaks as well as to the reinfestation of treated areas.

2. Little is known about the host relationship of this insect. Specifically, knowledge is needed to determine the types of stands most likely to be infested; the effect of spruce budworm defoliation upon the growth, form, and value of individual trees; and the over-all effects of varying amounts of defoliation upon the stand.

3. An accurate method is needed for predicting farther in advance the proper time to commence aerial spraying operations.

B. Evaluation Studies

1. Further refinement and definition of the procedures for the aerial evaluating of budworm infestations are needed. This information is especially necessary for the training of aerial observers.

2. A standardized procedure and cooperative arrangements are necessary for the establishment and periodic evaluation of additional population trend sample plots.

C. Control Studies

1. Biological control studies. Natural control must ultimately be depended upon to keep the budworm in check; therefore, a thorough knowledge of the role of parasites, diseases and climate is essential. Studies of natural control are in progress, but they should be stepped up.

2. Silvicultural control studies. In the East cutting practices have been developed and applied to prevent or at least minimize spruce budworm outbreaks. In the Northwest nothing has been done to explore the possibilities of this method of control.

3. Chemical control studies. The chemical control techniques which are available provide satisfactory control at reasonable costs. However, further refinements along the following lines are needed:

   a. To develop a simple, small-scale screening technique for testing insecticides which may be cheaper or more effective than the DDT formulation currently employed.

   b. To determine the possibilities of treating the small larvae so as to reduce the amount of defoliation in the year of treatment and to extend the time available for spraying.

   c. To evaluate the efficiency of different types of aircraft, the effects of varying application heights, and the effectiveness of various spray distribution systems.

Research Priorities

Because of the interrelationships between the problems listed above, it is difficult to set priorities by individual studies. The following list of priorities is based more upon the possibility of the work being done than upon relative importance:

1. Host relationships.
2. Aerial survey evaluation standards.
3. Population trend sample plots.
4. Parasites and predators.
5. Effect of climatic conditions.
6. Chemical control.
7. Dispersal characteristics.
8. Diseases.
9. Silvicultural control.

DOUGLAS FIR BEETLE

Importance of Problem

In Oregon and Washington the Douglas fir beetle has killed far more Douglas fir than any other insect. Its killing is sporadic, high in some years and low in others. Commonly the beetle builds up to epidemic numbers in windthrown and fire-killed trees. When conditions are right for it, the beetle will kill a billion or more board feet of timber in a single year, as it did in 1951 and 1952 (13). The beetle-killed trees scattered through the forest greatly increase the

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RES

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November 16, 1953

R. L. Furniss, In Charge, Portland Laboratory
Portland, Oregon

An Evaluation of Forest Insect and Disease Research Needs in Oregon and Washington. Part I - Insects

Enclosed are 15 copies of PART I - INSECTS of the Northwest Forest Pest Action Committee's report "An Evaluation of Forest Insect and Disease Research Needs in Oregon and Washington." This report was prepared by a work committee consisting of:

C. W. Richen, Chairman
A. W. Moltke
R. B. Wilson
E. F. Heacox
W. D. Hagenstein
C. G. Jorgensen
J. B. Woods, Jr.
D. R. Hopkins
V. D. Bronson

The work committee was formed last December at the time of the Western Forestry and Conservation Association meeting in Victoria, B. D. The work committee members did a great deal of work and came up with an evaluation of needs that will be very helpful in this region. Many individuals not on the work committee also contributed to the report. We acted in an advisory capacity, providing the technical information that was requested.

As you know the entire report was discussed at the recent meeting of the Forest Pest Action Committee and was adopted by the committee at large.

Copies of the part on insects are being provided for each of the laboratories in the Division. Some of the copies were distributed at the recent Work Conference at Pullman and Moscow. The others are being mailed out today. No additional copies are available at present. The committee plans to make some slight editorial changes in the report and to reissue it in quantity. At that time, we will be glad to provide copies to any who have need for them.

R. L. Furniss

cc: All stations
Mr. Keen

Mr. C. B. Eaton, Berkeley 4, California

P.S. At the work conference, someone said that you were interested in receiving a copy of Part #2 on Diseases. This part was processed in a very limited edition, consequently we do not have an extra copy. When the report is reissued, we will make sure that you receive a copy.

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fire hazard. At present the only feasible method of control is by salvaging the infested trees. This is of limited effectiveness. Research to develop methods of prevention and control, particularly through forest management practices, is urgently needed.

Research to Date

Most of the available information regarding the Douglas fir beetle in Washington and Oregon has been obtained from studies initiated in southwest Oregon in 1946. Various phases of the work have been carried out by the Bureau of Entomology and Plant Quarantine, Weyerhaeuser Timber Company, Oregon State Board of Forestry, Pacific Northwest Forest and Range Experiment Station, and the Division of Forest Pathology. The investigations have been the absolute minimum for meeting the essential needs for making surveys and formulating preliminary control recommendations. The following work has been done:

A. Biology

Preliminary studies have indicated that the behavior of the Douglas fir beetle differs considerably in the Douglas fir region from its behavior in the Rocky Mountain region where more intensive studies have been made (3).

B. Ecology

It has been shown that beetle outbreaks usually follow forest fires and blowdowns and that trees weakened by the tussock moth, spruce budworm, and other leaf feeders are highly susceptible to the Douglas fir beetle. In some cases outbreaks have occurred without detectable contributing causes.

C. Silviculture

Little is known about the relation of this beetle to the silviculture of Douglas fir. Mature and overmature stands usually are favored for attack. There is evidence that the attacked trees are less vigorous than the average tree in a stand, but the difference is slight.

D. Natural Control

A few studies have been made of natural control agencies. Parasites and predators appear to be important and insect diseases and nematodes may be of importance.

E. Applied Control

Peeling trees and logs with or without burning has been tried in the Rocky Mountain region with varying results. Penetrating oil sprays have killed beetle broods where the bark was not too thick.

F. Survey Methods

Aerial sketch mapping procedures for detecting and evaluating outbreaks

have been developed and applied. Tests to develop aerial photo survey methods have been undertaken with promising results.

Research Needs

It is recommended that investigations be conducted along six major lines as follows:

A. Appraisal of the Douglas fir beetle problem

Summarize the information on the history of outbreaks, their periodicity, the losses inflicted, and their economic significance. Develop and set up a survey system for recording the long-term trends of infestation in relation to the possible causes.

B. Additional study on the biology of the beetle

Present information on the seasonal history and habits of the beetle, particularly in the Douglas fir region, should be strengthened. More information is needed on the emergence and flight periods, the distance of flight, and the influences that attract or repel the adults.

C. Studies of the ecological relationships

Studies are needed on the types of trees attacked during various stages in the development of outbreaks and to determine what factors affect the beetle-susceptibility of individual trees and of forest stands.

Host resistance needs to be studied. This includes the characteristics of individual resistant trees, the influence of pitch flow on brood development, and the genetic differences of Douglas fir strains.

The interrelationships between Douglas fir beetle attacks and tree diseases, windthrow, fires, and defoliation need to be studied further; also the effects of climatic conditions, such as drought, in making stands more susceptible.

D. Development of preventive control through forest management

Some problems needing study are the influence of cutting practices, rotation age, thinnings, age-class composition, and species composition on beetle populations. The value of crown and risk classifications in preventive control needs investigation. The question is, can outbreaks be prevented or controlled through forest management practices?

E. Studies of natural control

There is vital need for more information on natural control. How does natural control operate at the beginning, at the peak, and during the decline of outbreaks? Natural control factors needing evaluation are parasites, predators, diseases, and climatic conditions.

Studies are needed to recognize more accurately the first signs of developing outbreaks and to interpret the early signs of declining outbreaks.

F. Development of direct control methods

The formulation and application of bark penetrating sprays should be studied. The value of systemic poisons applied through the foliage or by cambium injection should be determined. A most important question to be answered is when direct control measures should be applied. This requires a thorough knowledge of the epidemiology of this beetle, so that trends can be predicted, both with and without control.

Research Priorities

The Douglas fir beetle research needs are listed above in the order of their relative importance, taking into account the fact that some projects are prerequisite to others.

WESTERN PINE BEETLE

Importance of Problem

The western pine beetle has caused more damage to the forests of Oregon and Washington than any other insect (22). If all the timber killed by this beetle during the period 1921 to 1950 could be recovered it would be enough to run all the pine mills at their present production for nearly 10 years. In 1932 killing by the western pine beetle reached a peak of 1,820,000,000 board feet. Since then losses have declined due to notable progress in control through the logging of beetle-susceptible trees and to a series of years favorable to tree growth. However, losses still total between 150 and 200 million board feet annually and the need to improve prevention and control measures through research continues.

Research to Date

More research has been done on the western pine beetle than on any other forest insect in the West. For many years the investigations of the Bureau of Entomology and Plant Quarantine in Oregon, Washington and California were concentrated on this insect. All the work done to date has been summarized and is awaiting publication (18).

The habits of the western pine beetle and its host relationships have been worked out in great detail. Direct control measures were developed early in the investigations and were extensively applied. More recently, methods for detecting beetle-susceptible trees were perfected (17) (21). This information has been put to wide practical use to effect indirect control through the selective cutting of the susceptible trees. Current studies are concentrated on determining the effects of cutting methods upon mortality caused by the pine beetle.

Research Needs

There is a strong need for additional research on control methods. To date sanitation-salvage logging and direct control by felling, peeling, and burning are the only practical control methods. Direct control is too costly and slow by existing methods. Considerable can be done through sanitation-salvage logging, but it is not wise to depend entirely on this method of control. To do so makes a forester out of the beetle. It determines where, when, and what to cut, which is seldom compatible with long-range economic and silvicultural objectives of forest management.

The following research is needed:

A. Development of direct control methods

Chemicals, such as systemics, to be applied wide-scale rather than to individual trees, should be investigated.

B. Development of preventive control through forest management

Killing by the western pine beetle on some sanitized areas shows a need to continue and expand studies of the beetle in selectively cut stands.

C. Studies of ecological relationships

Investigations to determine what attracts the beetle to a particular tree are basic for developing sound forest management practices.

D. Studies of natural control

Studies of the natural rise and fall of outbreaks and their causes also should provide information that will help improve the methods of indirect control through forest management.

E. Survey studies

Existing surveys to detect and evaluate outbreaks are highly developed. However, preliminary tests with aerial photos give promise of increased efficiency and economy. The tests should be continued.

Research Priorities

The western pine beetle research needs are listed above in the order of their current importance.

FIR ENGRAVER BEETLES

Importance of Problem

Silver fir on extensive areas in northern Washington is dead and dying. This is of great importance to the pulp and paper industry of the area. Preliminary studies have shown that fir engraver beetles (Pseudohylesinus) and associated fungi are the primary killing agents. No control measures have yet been developed, principally because the beetles characteristically rear broods in trees for several years before the trees are killed. Thus the usual methods of bark beetle control by treating infested, recently dead trees are not effective.

Research to Date

In 1949 the Bureau of Entomology and Plant Quarantine started a study of engraver beetle outbreaks in silver fir stands of western Washington. From 1949 through 1951 the study was conducted cooperatively with the University of Washington (7). In 1952 the study was reduced to an annual evaluation of the trends of infestation. The study was undertaken to determine the extent and nature of damage and to investigate the possibility of developing control measures. Through this study preliminary knowledge has been gained on the biology of the insects, the types of trees infested and trends of infestation.

Research Needs

Following is a list of investigations needed to give better information on the fir engraver beetles and to form a basis for developing control:

A. Biological Studies

Facts are needed on periods of emergence, flight habits, and other characteristics of these insects.

B. Ecological Relationships

Studies are needed to determine the types of trees and stands attacked; which trees are susceptible and whether any are resistant to attack; and whether tree diseases, defoliation, windthrow, fire, and drought contribute to outbreaks of the beetles.

C. Studies of Natural Control

There is urgent need for detailed information on natural control and how it operates. Continued studies of population trends are essential.

D. Development of Direct Control Methods

Fir engraver beetles often attack in patchwise fashion in trees for several years before the trees are killed. This makes it difficult to detect all the trees with broods. Rot often follows the beetles and seriously reduces the value of trees before they are killed. As a result the usual salvage logging of dead trees

removes only part of the beetles and is not an effective control measure. For these reasons the development of direct control methods is urgent.

E. Survey Studies

The habits of these beetles present difficult survey problems that must be resolved.

Research Priorities

Research needs on fir engraver beetles are listed above in the order of their present importance, taking into account that they are largely interdependent.

MOUNTAIN PINE BEETLE

Importance of Problem

Sugar pine, white pine, lodgepole pine, and ponderosa pine are extensively killed by the mountain pine beetle. Effective direct control measures have been worked out and can be applied where the economic values warrant. In ponderosa pine the greatest damage is caused to young stands that are just approaching merchantable size. Damage of this kind is increasing and promises soon to become a major problem on cutover lands in the pine region.

Research to Date

Considerable knowledge has already been gained on the biology and environmental habits of this bark beetle, largely in other parts of the West (10). Direct control measures vary with the region and type of infested timber, particularly whether the trees are thin or thick barked. Common control measures are: (1) feeling infested trees and burning the bark; (2) felling and peeling bark; (3) felling and sun curing; (4) spraying trees with fuel oil and burning them either after felling or while standing; and (5) spraying trees with penetrating oils to which a toxicant has been added.

Research Needs

Research is needed to develop more economical and practical control methods, both direct and indirect, because mountain pine beetle outbreaks are a constant threat. Since most of the loss from this beetle in the past has been in the less valuable lodgepole pine, not too much alarm has been generated when infestations occurred. As this tree becomes more useful, the need for prompt control will be evident. More pressing is the need to determine effective ways to manage young ponderosa pine stands so as to keep threatened losses to a minimum. Long-term studies to this end should be undertaken immediately.

Second Priority Group

Insects in this group are not currently in widespread epidemic form and generally they do not constitute as important an economic problem as those in the first priority group.

CONE AND SEED INSECTS

Research to Date

The cone and seed insects include a number of cone moths, cone beetles, cone maggots, cone borers and seed chalcids. There was a considerable amount of early research on many of these insects at Ashland, Oregon from 1914 to 1916. This early work and the information assembled in the intervening years have recently been summarized in manuscript (15).

Research Needs

Research should be concentrated on those insects affecting Douglas fir seed. Additional research is needed on the biology of some of these insects, as a basis for experimental control. Direct control might be economically feasible to facilitate seed collections and to increase natural seeding on clearcut areas.

IPS IN PONDEROSA PINE

Research to Date

Considerable research on Ips has been done (16) Its life history is well known as is its relationship to climate and environment.

Research Needs

Investigations are needed on both silvicultural and direct control of this insect under conditions of intensive forestry. Research work can be conducted in conjunction with the management of ponderosa pine stands in eastern Oregon and Washington.

SITKA SPRUCE WEEVIL

Research to Date

A study of the Sitka spruce weevil was started in 1948 and is being conducted jointly by Crown-Zellerbach Corporation and the Bureau of Entomology and Plant Quarantine. The primary objective of the study is to determine the effect of the weevils on the growth and quality of Sitka spruce, especially in plantations.

Research Needs

The current research project should be completed to determine whether the damage caused by the insect is sufficient to warrant further research.

HEMLOCK LOOPER

Research to Date

Considerable research has been done on the hemlock looper, particularly by the Canadians (14). The life history of the looper is well established. Outbreaks are naturally controlled about three years after starting by the action of parasites, predators and disease, including a polyhedral virus. Aerial spraying with lead arsenate and DDT, has been successfully used to control outbreaks.

Research Needs

Research is needed on the causes of outbreaks, methods of preventing outbreaks through forest management, and possible control by the aerial application of disease organisms such as viruses.

PINE BUTTERFLY

Research to Date

The biology and habits of the pine butterfly are fairly well known (9). Recent tests have shown that it can be controlled by aerial spraying with DDT.

Research Needs

The pine butterfly, when epidemic, is very destructive to ponderosa pine forests. Only a few epidemics are on record. One is in progress in southern Idaho. Current studies of the butterfly and its control in Idaho probably are sufficient for present needs in Oregon and Washington.

Third Priority Group

This group includes insects that are currently inactive or for which sufficient information is available so that further research can be postponed in favor of more pressing problems. Immediate research on some of these insects may be desirable by agencies or companies to which they present a local problem.

LODGEPOLE PINE SAWFLY

Periodically the lodgepole pine sawfly becomes extensively epidemic on lodgepole. At present some 50,000 acres in the central Cascades of Oregon are heavily infested by this insect. Very little is known about this insect, its natural control, and its effect upon the forest. It can be controlled by aerial spraying with DDT.

GREEN SPRUCE APHID

There has been little research on this insect. Periodically it becomes epidemic on Sitka spruce along the tideland of Oregon and Washington. The heavily attacked trees are stripped of their old foliage, leaving only the new growth. Successive defoliation and the attacks of bark beetles cause killing, but so far the problem has not become of much economic importance.

DOUGLAS FIR TUSSOCK MOTH

Considerable information is available on the biology of this insect (2). Epidemics have occurred at wide intervals, causing extensive killing, often in combination with the Douglas Fir beetle. An outbreak in northern Idaho in 1946 and 1947 was effectively controlled by aerial spraying with DDT. Control work on this insect might include the use of other sprays beside the standard DDT. Aerial dissemination of virus organisms for control should be investigated. Information is needed on the causes of outbreaks.

PANDORA MOTH

Considerable information is available on the life history and natural enemies of the Pandora moth (20). It is of minor importance, as it is a tree killer only in very severe epidemics. Epidemics occur rarely and principally in areas with loose pumice soil. When feasible, aerial spraying with DDT should be tried as a method of applied control.

HEMLOCK SAWFLY

Information on the biology of the hemlock sawfly is fairly complete (11). This insect is not particularly important in Oregon and Washington. Therefore, it is recommended that we rely principally upon the research being done in Alaska and British Columbia where the sawfly is of considerable importance.

BLACK-HEADED BUDWORM

Periodically the black-headed budworm becomes epidemic in the coastal hemlock forests of Washington, so far without causing extensive killing. It is much more important in British Columbia and Alaska. The Canadians have learned much about the budworm (1). It is suggested that the research being done in Canada and Alaska should continue to lead the way.

WOOD PRODUCTS INSECTS

Considerable information is available on the great variety of wood products insects. As they normally do not occur in epidemic outbreaks, the primary importance of these insects in forest management is in their effect on the deterioration and degrade of fire-killed, beetle-killed and windthrown timber. The one problem in need of special attention is the prevention of ambrosia beetle attacks on logs. Locally such attacks are of considerable importance in causing degrade. Special studies of this problem may be warranted.

OTHER INSECTS

Other insects not listed above probably will need to be studied. As the virgin forests of the region are harvested the relative importance of the insects will change. The species that thrive best in extensive stands of old growth timber will become less important than the insects that attack and kill young trees. Defoliators probably will become more important. Damage now ignored will become economically significant. There is the ever-present possibility that some destructive foreign insect may become established.

PARTICIPANTS IN FOREST INSECT RESEARCH PROGRAM

Agencies Currently Conducting Forest Insect Research

The agencies conducting the majority of the forest insect research in Oregon and Washington at the present time are the Bureau of Entomology and Plant Quarantine, the Oregon State Board of Forestry, and the Weyerhaeuser Timber Company.

The staff of the Portland Forest Insect Laboratory of the Bureau of Entomology and Plant Quarantine includes five full-time entomologists and one pilot-forester. Three of these men and from 2 to 3 seasonal field assistants work on research. Current projects include studies of the Douglas fir beetle, the spruce budworm, the western pine beetle, fir engraver beetles, the Sitka spruce weevil, and survey methods.

The Oregon State Board of Forestry has one entomologist, one forester and two field assistants working on Douglas fir beetle studies; one forester and one field assistant working on spruce budworm studies; and three foresters working part-time on survey methods and chemical control studies.

The Weyerhaeuser Timber Company is employing two entomologists, and three foresters part-time on Douglas fir beetle studies. Other foresters from the Company's research staff devote at least part of their time to studies of the western pine beetle and survey methods.

In addition to those mentioned above, numberous other agencies are contributing to forest insect research. In Table 2 these agencies are listed and the studies in which they are participating are indicated.

Participants in Future Research

The forest insect research needs call for material increases in the present research organizations. In addition a carefully planned and well coordinated program will do much to improve the effectiveness of current participants and to enlist additional cooperators, as follows:

A. Forest Managing Agencies - Among the many agencies which manage forest lands in the Northwest there are numerous people who are well qualified and have an excellent opportunity to make valuable contributions to forest insect research.

An example of this type of assistance is the work this group did during the 1953 season in the establishment and measurement of permanent plots to record the trends of defoliator infestations. Personnel of the Bureau of Entomology and Plant Quarantine prepared instructions for the establishment of the plots and the collection and compilation of data. The Industrial Forestry Association then arranged meetings in Oregon and Washington at which the project was explained. Various foresters then accepted assignments for the establishment and measurement of specified plots in their areas.

Similar procedures could be followed for gathering data for bark beetle studies; for spruce budworm host relationship studies; and for numerous other phases of forest insect research.

Among the agencies which could provide the type of assistance suggested above are the following:

U. S. Forest Service
Bureau of Land Management
U. S. Indian Service
Oregon State Board of Forestry
Washington State Division of Forestry
Forest Industries

B. Colleges and Universities - With trained technicians, laboratory facilities, and the services of graduate students, colleges and universities in the Northwest could likewise provide invaluable assistance to the forest insect research program.

Such institutions could be particularly helpful in biological studies of the insects and in the development of techniques for the testing of insecticides. Many physiological, ecological and other studies which in the long run are of fundamental importance, but which have no immediate application in control, can best be carried on by graduate students and other research workers in the colleges and universities.

Representatives of Washington State College, the University of Washington, and Oregon State College have already indicated their willingness to help. It appears that all that is required is that they be shown where their help is most needed and that the projects be financed.

C. The Chemical Industry - Chemical companies are naturally interested in developing markets for their products. Many of these companies have research staffs and facilities for testing insecticides and developing methods of application.

As was explained in the section on chemical control, each year these companies offer new chemicals as insecticides. At present there are no standard techniques for testing these materials against forest insects.

Local representatives of these companies have already indicated that they will provide the services of their chemists and their laboratory facilities to assist in the development of testing techniques and to conduct servicing tests.

D. Other Possible Participants - In addition to those listed above there are numerous other agencies which might contribute to forest insect research. The following are examples of these possible participants:

Research foundations
The equipment industry
Aerial spraying and dusting concerns.

BIBLIOGRAPHY

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TABLE 1

SUMMARY OF INFESTATION CENTERS MAPPED ON 1952 AERIAL SURVEYS

Insect	Washington		Oregon		Total	
	No. of Centers	Acres	No. of Centers	Acres	No. of Centers	Acres
DEFOLIATORS						
Spruce Budworm	11	147,040	25	1,431,520	36	1,578,560
Hemlock Looper	41	12,720			41	12,720
Lodgepole Sawfly			5	19,820	5	19,820
Lodgepole Needle Miner			2	9,300	2	9,300
Larch Budworm	3	2,080			3	2,080
Pine Budworm	4	480			4	480
Unknown	6	5,600			6	5,600
Subtotal	65	167,920	32	1,460,640	97	1,628,560
BARK BEETLES						
Douglas Fir Beetle	272	458,400	91 1/	4,111,730	363	4,570,130
Western Pine Beetle	45	225,440	140	448,350	185	673,790
Mountain Pine Beetle	200	172,040	70	98,700	270	270,740
Ips sp.	22	9,120	211	82,820	233	91,940
E. Spruce Beetle	1	1,120			1	1,120
Pseudohylesinus sp.	22	145,760	21	16,680	43	162,440
Scolytus sp.	17	12,960			17	12,960
Subtotal	579	1,024,480	533	4,758,280	1,112	5,783,120
GRAND TOTAL	644	1,192,760	565	6,218,920	1,209	7,411,680

1/ The Douglas fir beetle epidemic in western Oregon has been considered as one large center of infestation of 3,893,920 acres, to which has been added the other centers recorded during the season.

TABLE 2

PRESENT PARTICIPANTS IN RESEARCH ON FOREST INSECT PROBLEMS IN OREGON AND WASHINGTON - APRIL 1953.

	Douglas fir beetle	Spruce Budworm	Survey methods	Western pine beetle	Pseudohylesinus	Cone & seed insects	Mountain pine beetle	Ips	Sitka spruce weevil	Hemlock looper	Pine butterfly
FEDERAL AGENCIES											
Bur. Entomology & P. Q.	x	x	x	x	x				x		
Division of Forest Pathology	x										
Forest & Range Exp. Station	x		x								
Forest Service		x		x							
Bur. Land Management	x		x								
Indian Service				x							
STATE AGENCIES											
Oregon State Board of Forestry	x	x	x								
Washington State Div. of For.			x								
College of For., U. of Wash.	x	x			x						
Food Technology Dept., O.S.C.	x										
PRIVATE ORGANIZATIONS											
Industrial Forestry Assn.	x										
Western Pine Association				x							
Tree Farm Management			x								
Crown Zellerbach Corporation									x		
Weyerhaeuser Timber Company	x		x	x							